Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at http://about.jstor.org/participate-jstor/individuals/early-journal-content.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact support@jstor.org.

THE POPULATION PROBLEM

By RAYMOND PEARL
The Johns Hopkins University

In the opening chapters of the first edition of his "Essay on the Principle of Population," T. R. Malthus said: "I think I may fairly make two postulata. First, That food is necessary to the existence of man. Secondly, That the passion between the sexes is necessary, and will remain nearly in its present state, . . . Assuming, then, my postulata as granted, I say, that the power of population is indefinitely greater than the power of the earth to produce subsistence for man." In the century and a quarter since these words were published the evidence not only of their truth but also of their profound wisdom has multiplied manyfold. Malthus could know as facts of experience, when he wrote in 1798, only what was behind him. What was to happen in the nineteenth century he could only conjecture.

Proceeding from the earliest to one of the most recent scientific studies of the problem of world population, it is to be noted that Griffith Taylor, in his original and thoughtful paper on "The Distribution of Future White Settlement" in the July, 1922, number of the *Geographical Review* envisages clearly the coming limitation of the earth's population, by reason of its saturation in respect of means of subsistence. The time factor in this population saturation, is one about which there may be difference of opinion. But it really matters little whether one takes Knibbs's estimate of 450 years quoted by Taylor, p. 402, or that author's own suggested figure of about two centuries or the perhaps even shorter estimate to which my own mathematical studies have tentatively led me. The important consideration is that population, so far as we know, always has grown and certainly is now growing at a rate which, if continued, will some time completely populate the habitable portions of the earth with a density which will be the maximum consistent with the continued existence of human beings.

EXPLANATION OF FIGURE 1

Figure 1 of this article gives a picture of some aspects, at least, of what has happened since the beginning of the nineteenth century. It will pay us to examine it with some care, because it presents the problem that worried Malthus, as it exists here and now. It will appear with startling emphasis, that nothing which has happened since 1798 has in the least degree mitigated or softened or altered in any true sense the relentless insistence of Malthus's logic. On the contrary, the developments of the last century have made it far plainer even than it was to so clear-visioned a major prophet as he was, that the population of the world cannot go on increasing at anything like the rate of growth that has prevailed in the past more than a short time longer.

This diagram is constructed from official figures, conveniently compiled in the annual volumes of the "Statistical Abstract of the United States." It is made according to the following plan. The absolute values for population and for the several other items of production, trade, and the like, included in the diagram, were taken as of value 100 in the year 1800, and then at each subsequent point on the diagram the absolute figures are reduced to relative values on the basis of the 1800 figure taken as 100. The only exception to this procedure is in the case of railways and telegraphs, which had not come into existence in a statistically significant sense in 1800. In those cases, the figures of their first appearance in the statistics (1830 in the case of railways, and 1850 in the case of telegraphs) are taken as 100, and the subsequent values are referred to the initial value as a base. The relative figures so obtained were then plotted on a logarithmic scale. The virtues of such a scale of plotting are, in the present case, twofold. In the first place, it enables us to include in one diagram of moderate dimensions the enormous range of variation exhibited by certain of the items. In the second place, it is a property of logarithmic charts that the *slopes* or trends of all lines are directly and visually comparable one with another. This is not true of charts plotted on an arithmetic scale, unless the absolute values plotted chance to be of approximately the same magnitude. The figures on the left hand margin of the diagram are to be interpreted in this way. If any relative value rises to the line marked 1,000, it means that the item exhibiting this figure has increased tenfold. If it rises to the line 10,000, it means that the item has increased, in the period covered, a hundredfold; if to the 100,000 line, it has increased a thousandfold.

The original data upon which the diagram is based, together with the calculated relative values, are presented in Table I. It is to be noted, as a matter of course, that the figures of Table I cannot possibly be meticulously accurate. They represent, in some of the items, only rough statistical estimates. But they cannot possibly be so far in error as to affect sensibly the general lesson which the diagram teaches.

THE WORLD'S RELATIVE PROGRESS IN POPULATION AND PRODUCTION

With these explanations of the construction of the diagram, we may proceed to see what it means. In the first place it appears that the world's population has increased in the century a little less than two and a half times. This is, in itself, not an extraordinary figure and would appear to be nothing to be in any way alarmed about. It is far smaller than the rate of population increase under special circumstances, where the population of a particularly favored area may double itself in fifteen to twenty years.

The point of real interest in the diagram, the thing which gave purpose to the writing of this article, is that *the slope of every other line on the chart is*

TABLE I—WORLD'S DEVELOPMENT OF POPULATION, PRODUCTION, VESSEL, TONNAGE, AND COMMERCE: 1800 TO 1918

YEAR	POPULATION		COMMERCE TOTAL		TONNAGE SAIL AND STEAM		RAILWAYS		TELEGRAPHS		PRODUCTION OF					
											COTTON		COAL		PIG IRON	
	ABSOLUTE MILLIONS	RELATIVE	ABSOLUTE MILLIONS	RELATIVE	ABSOLUTE	RELATIVE	ABSOLUTE THOUSAND MILES	RELATIVE	ABSOLUTE THOUSAND MILES	RELATIVE	ABSOLUTE MILLION POUNDS	RELATIVE	ABSOLUTE MILLION SHORT TONS	RELATIVE	ABSOLUTE MILLION TONS	RELATIVE
1800	640	100	1,479	100	4,026	100	—	—	—	—	520	100	11.6	100	0.8	100
1820	780	122	1,659	112	5,834	145	—	—	—	—	630	121	17.2	148	1.0	125
1830	847	132	1,981	134	7,211	179	0.2	100	—	—	820	158	25.1	216	1.8	225
1840	950	148	2,789	189	9,380	233	5.4	2,700	—	—	1,310	252	44.8	386	2.7	337
1850	1,075	168	4,049	274	12,334	306	24.0	12,000	5	100	1,435	276	81.4	702	4.7	587
1860	1,205	188	7,246	490	16,600	412	67.4	33,700	100	2,000	2,551	491	142.3	1,227	7.2	900
1870	1,310	205	10,663	721	15,940	396	139.9	69,950	281	5,620	2,775	534	213.4	1,840	11.9	1,487
1880	1,439	225	14,761	998	20,280	504	224.9	112,450	440	8,800	3,601	693	340.0	2,931	18.0	2,250
1890	1,488	233	17,519	1,185	17,461	434	390.0	195,000	768	15,360	5,600	1,077	466.0	4,017	27.2	3,400
1900	1,543	241	20,105	1,359	20,531	510	500.0	250,000	1,180	23,600	6,247	1,201	800.0	6,897	40.4	5,050
1906	1,579	247	27,148	1,854	25,522	634	564.0	282,000	1,200	24,000	7,650	1,471	885.0	7,629	58.7	7,337
1910	1,616	253	33,634	2,274	26,670	662	637.0	318,500	1,307	26,140	9,013	1,733	1,141.6	9,841	65.8	8,225
1911	1,630	255	35,909	2,428	28,298	703	666.0	333,000	1,356	27,120	10,634	2,045	1,309.6	11,290	62.4	7,800
1912	1,643	257	39,570	2,675	29,061	722	683.4	341,700	1,400	28,000	10,301	1,981	1,377.0	11,871	72.8	9,100
1913	1,652	258	40,420	2,733	30,408	755	690.2	345,100	1,462	29,240	10,809	2,079	1,478.0	12,741	77.9	9,737
1914	1,661	260	37,760	2,553	31,674	787	703.5	351,750	1,489	29,780	11,933	2,295	1,346.0	11,603	56.8	7,100
1915	1,672	261	31,302	2,116	31,693	787	717.5	358,750	1,526	30,520	8,805	1,693	1,169.6	10,083	59.0	7,375
1916	1,692	264	46,523	3,146	31,293	777	720.3	360,150	1,564	31,280	9,047	1,740	1,242.9	10,715	71.4	8,925
1917	1,693	265	52,781	3,569	29,805	740	729.8	364,900	1,568	31,360	8,705	1,674	1,317.9	11,361	64.6	8,075
1918	1,699	265	62,802	4,246	31,139	773	732.8	366,400	1,586	31,720	8,845	1,701	—	—	62.0	7,750

far steeper than that of the population line. Thus it appears that, while the population was increasing two and a half times, the world's coal production and pig iron production increased from fifty to seventy times and by 1917 had increased nearly 100 fold over the conditions of 1800. The world's cotton production increased in the same period twentyfold; the world's commerce, a little more than that; the world's shipping increased something like eightfold, while the railway mileage increased, in the period from 1830 to 1917, by roughly 3,000 fold, and the telegraphs 300 fold.

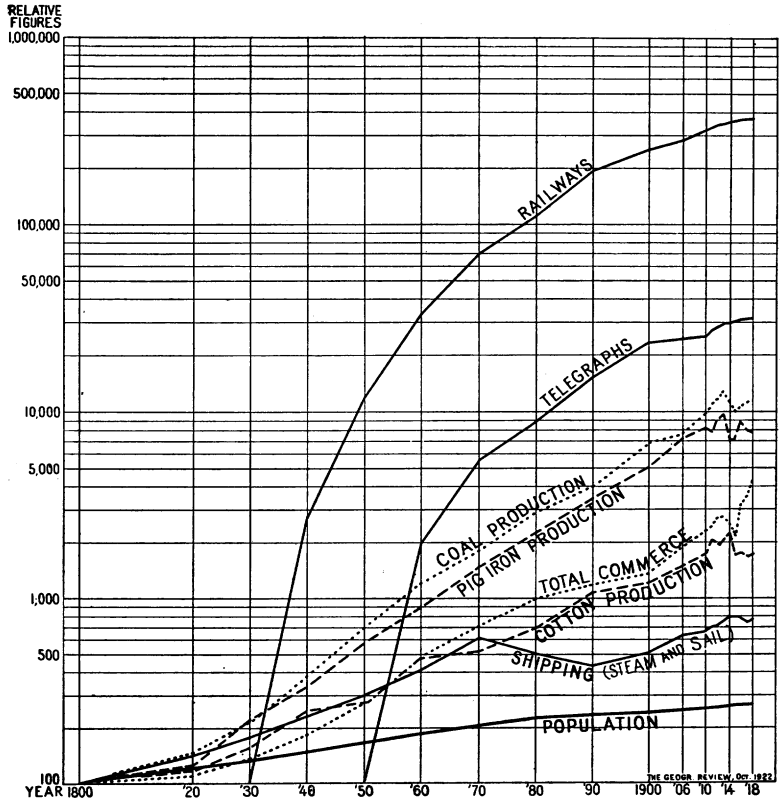

FIG. 1—Diagram showing the progress of the world's population and production of certain materials in the nineteenth century.

In the face of such figures as these, one may well ask, "Where are we going?" No sensible person will, for a moment, suppose that such lines of this diagram as those for cotton production, coal production, or pig iron production can go on indefinitely increasing at the rate shown in the 117 years covered. It would be manifestly absurd. Yet, on the other hand, it must be remembered that these figures are world figures, approximate if one pleases, but on the whole certainly not far from the true, unknown, facts. This consideration means that the population of the world, in one way or another, has used up in the business of carrying on its life all of the coal, all of the pig iron, and all of the cotton for which the production trends are indicated on the diagram. There is no such thing as "interworld" trade. Therefore it cannot be asserted that a part of this production went for export and consequently need not be worried about. Trade relations have still to be established with the other planets. When we look at the facts of *world* production, we are also, and implicitly, setting before ourselves the data of *world* consumption, using consumption in the broad sense of usage plus wastage.

Now it appears equally to be true that the whole fiber of our social organization is bound up with the consumption of about the indicated amounts of products. In other words, so much coal and so much pig iron and so much cotton were produced in the last century because the world's people needed them, or, at least, thought they needed them to maintain and continue their lives, individually and collectively, in the way they were doing and presumably wanted to do. Put in another way, there seems no escape from the conclusion that the present stage of the development of the world's civilization requires about the ratios of production to population shown on the chart in order to maintain itself and continue at its present standards of living.

But there at once follows a most significant corollary from this. If it be granted that the coal and pig iron lines, for example, cannot by any possibility be projected for another century or two along the same lines that their production has followed during the past century, then it must be that, unless the rate of increase of population slows up, the ratio between the production of these goods and the population which has been maintained in the past cannot possibly be continued in the future.

There may be those inclined to interpret the diagram in a directly opposite way; who will say that, since a given population is now able to produce, owing to all the developments of knowledge which have occurred, such vastly greater quantities of all these necessities than they were able to in 1800, there appears no reason why the process should not go on at the same rate in the next century that it has in the one just past, it being presumed that mankind will increase in the organized intelligence and awareness which constitutes applied science. This view overlooks the fact that besides the human element involved in production, there is another of even greater importance which finally limits the process. It is, that the volume and the surface of the planet on which we live are strictly fixed quantities. This fact sets a limit, if no other does, to the indefinite projection of these straight lines of production trend which make angles of 30 to 45 degrees with the horizontal. For example, one would not have to project the coal production line, along the course it has followed during the nineteenth century, over many years before it would reach a point where it would indicate a produced tonnage such that the entire globe would have to be solid coal to permit of its realization. Eventually there must come a turn in these production lines. One suspects that it may have already come in the case of pig iron and cotton.

The curves for railways and telegraphs are interesting in this connection. On the whole, the world has finished the major portion of its railway building. There will, of course, be many more miles of railway built as time goes on; but the additions will clearly be at a much slower rate than has been the case from 1830 up to the present time. In other words, the world is nearing a stage of saturation in respect of railways. It has, roughly speaking, about all it needs.

TRENDS OF THE WORLD'S FOOD PRODUCTION

So far nothing has been said about food, the most important single item in human subsistence. We come here upon much less secure ground, statistically speaking, because there are no particularly accurate world figures for even the most important of crops. The data that are available are distinctly rough estimates, except in the case of sugar, where, owing to the nature of the manufacturing processes involved, the total production is rather accurately known. For the other crops the estimates are, in general, simply the summed returns from countries which have a system of agricultural statistics. Probably this leaves out a significant proportion of the total production. But there is every reason to believe that the *trends* shown by the figures which are available are substantially in accord with what would be shown if accurate total figures were at hand. Inasmuch as it is only the general trend of the figures that we are interested in for the present purposes, the data set forth in Table II will suffice. The data are shown graphically in Figure 2.

From Figure 2 it appears that a process is going on in world food production which is precisely the same in kind, though different in degree, as is shown in Figure 1 for the production of other things than food. Until 1916 the food production curves were rising *at a more rapid rate* than the population curve. In the last three years of the chart the upsetting conditions of the war, combined with unfavorable seasons in many regions, caused an abrupt fall in the world's food production. But, leaving these years out of account, it is plain that the world's food consumption (for here as before production means consumption, in the broad sense, when we take the world as a whole) has increased faster in the last 20 years than has population. This is particularly marked in the case of the commodity sugar, which in some degree may be regarded as a food luxury.

It will be understood, of course, that not the whole of any one of the crops shown in Figure 1, is *directly* consumed as human food. In some cases, notably corn, the fraction that is thus directly consumed by human beings is relatively small. But indirectly and in converted form, through animals and manufactured products, the bulk of all edible farm crops contributes in greater or less degree to human nutrition. We eat the corn in the form of pork, we drink (or did drink) a good deal of barley as beer, we eat some of the oats as oatmeal, some as eggs, some as milk, and so on.

Now, a superficial view of the situation revealed in Figures 1 and 2 is likely to be extremely complacent. Population has grown since Malthus's day. Yes, about as he said it would. But Malthus quite overlooked the powers of man himself to make nature do his will. As the population has increased man has made the means of subsistence increase still faster. So far from population catching up with the means of subsistence, it is plainly out-distanced in the race. So will the unthinking interpret our charts.

TABLE II—WORLD PRODUCTION OF PRINCIPAL FOOD CROPS

YEAR	CORN	WHEAT	OATS	BARLEY	RYE	POTATOES	SUGAR
	MILLION BUSHELS	MILLION BUSHELS	MILLION BUSHELS	MILLION BUSHELS	MILLION BUSHELS	MILLION BUSHELS	MILLION POUNDS
1895	2,835	2,593	3,008	916	1,468	——	17,779
1900	2,793	2,641	3,166	960	1,558	4,382	19,370
1905	3,461	3,327	3,510	1,180	1,496	5,255	21,310
1910	4,032	3,575	4,182	1,389	1,673	5,275	33,415
1911	3,461	3,541	3,786	1,375	1,579	4,749	38,083
1912	4,055	3,760	4,585	1,457	1,901	5,873	35,585
1913	3,587	4,127	4,697	1,650	1,880	5,803	40,788
1914	3,878	3,486	4,035	1,463	1,597	——	41,972
1915	4,213	4,173	4,389	1,560	1,586	3,044	41,512
1916	3,101	2,279	3,941	1,437	530	1,720	37,069
1917	3,483	2,224	2,975	914	434	2,734	37,729
1918	3,038	2,818	3,052	1,077	529	——	38,375

But we are unable to convince ourselves that such complacency has any warrant. We believe that anyone who will take the trouble to read even the present article carefully and will ponder over the *facts* it presents, rejecting if he likes everything that savors of opinion or theory, will be bound to feel some misgivings about the world's ability to go on indefinitely increasing both its population and its average standard of consumption or of living. For precisely that is what we are now doing. The steeper slopes of the production with the population line can only mean (recalling always that we are dealing with the world figures) that the ratio of consumption to population has been steadily widening. But a widened consumption ratio represents a more extravagant standard of living. It can, broadly speaking, mean nothing else. If people, taken at random, consume (use and waste) more goods now than people did say 20 years ago, then plainly their standard of consumption has gone up.

RESULTS OF OTHER STUDIES

Space will not permit any exhaustive review of the literature, but the author of the present article desires to quote briefly from two recent writers on the general subject of population, in order to show that he does not stand alone in the views suggested. One of the most careful and thorough of recent students of the problem is Thompson. In rounding up the results of his study he says:

> Another conclusion which seems to me to be warranted is that population cannot continue to increase at its present rate without being more and more subjected to the actual want of food, provided the distribution of labor between agriculture and the non-agricultural industries continues in its present trend (the trend found in the more highly developed countries). Nor can a greater and greater proportion of the population be devoted to agriculture and the present rate of increase continue without checking a progressive standard of living. The non-agricultural industries are not yielding increasing returns in such ratio that they can furnish the necessary material means for a progressive standard to such a rapidly increasing population. Thus whatever the direction of development, a progressive standard of life and a population increasing from 1.5 per cent to 2.0 per cent a year cannot go on together for long, in a large part of the world. Therefore, either our present standard of living must be simplified as an increasing proportion of the population becomes rural or the present rate of increase of population must be lowered. Probably both must take place in order to have a really progressive civilization.

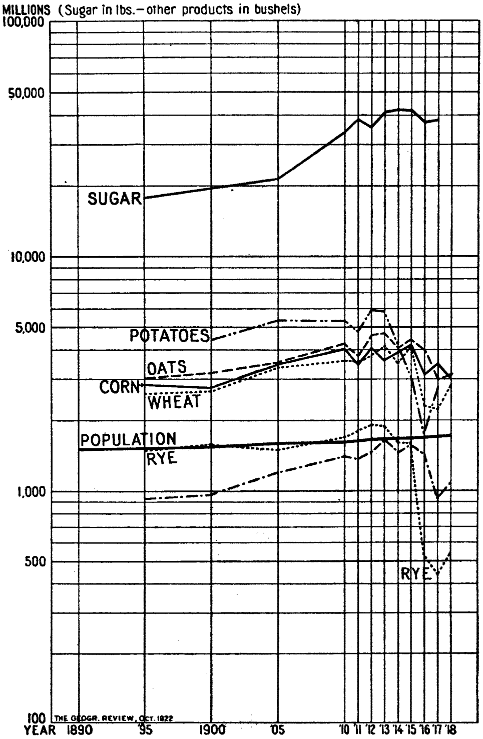

FIG. 2—Diagram showing progress in world food production in relation to population.

> To simplify our present standards of living does not necessarily mean a lowering of them. It means rather that a good many of the things of our civilization which we consider essential today may be found to be merely passing phases, induced by our rapid industrial development. We have become accustomed to think of civilization and culture and progress as of necessity involving all the complexities of our present existence. It is open to question, however, whether much of our present complexity is not a hindrance to real culture rather than an aid. There cannot be much doubt that as people are becoming more educated they are becoming more self-contained, and they begin to see that the way to get the most out of life is to put the most into it, and not to surround themselves with all the luxuries and baubles they can afford.
>
> But it is doubtful whether even such a simplification of life of the people of the more highly civilized nations will enable them to support in comparative comfort an ever-increasing proportion of their populations, or even the same proportion as at present, if it is not accompanied by a lower rate of natural increase of population. A slower rate of increase of population will give more time to adjust standards of life to surrounding conditions and to direct the course of progress; without it most of our efforts must be directed towards the more pressing of the problems of our present-day life. A greater and

greater control over the growth of population is essential to a growth of rational social control.[1]

Another leading student of the problem, East, has this to say in a recent paper:

> Let us think in terms of land. A careful study of the available statistics shows that, by and large, it takes about 2.5 acres to support each individual. Some self-supporting nations can make out with less, but only when they put all their efforts into cultivating their richest land; others with less efficient methods take much more. Taking this as the average figure, then, it is necessary to plow, plant, cultivate, or otherwise tend, some 37 million acres more land each year than was ever so treated before, if the nations of the earth are not to go hungry.
>
> It is a curious illustration of the general tendency of people to be optimistic about everything, that even many of our most eminent economists believe this wresting of additional food from the soil to be an easy task. They draw wonderful pictures of what science has done in the past few years, make roseate prophecies of similar advances in the future, and keep everyone happy with the idea that the human race has unlimited credit on Nature's bank. Never was logic more fallacious. The total land area of the globe, 33,000 million acres, seems large, it is true, but one cannot utilize all this area for raising crops. Take out the mountains, the deserts, the undrainable swamps, in short the areas not available for agriculture, and there is left about 13,000 million acres. Of this potential world farm some 5,000 million acres are now being cared for by the hand of man. According to our previous calculations, then, the maximum population the earth can support is a little over 5,000 millions. And here is the heart of the matter—the time when this important event would take place at the present rate of increase is not so far distant but that some of our grandchildren would live to see it. Mind, I do not say the world is going to fill up and run over like a tub within the next century or so. Of course it is not. The difficulties of digging out a living, the positive checks to population, will see to it that the present rate of increase diminishes, even if no other checks intervene. I am merely showing the meaning of this speed.
>
> In the second place, human genius is not doing for agriculture just what our economists seem to think. The industrialization of the Caucasian world which has gone on at such a rapid pace during the last fifty years has provided for more people, it is true. In fact, population increase, though rapidly rising, has not really caught up with the increase in production made possible by the multitude of mechanical inventions. But why has this come about? There is one reason and only one reason for the situation. We have had a reserve of new land to draw upon. Mechanical invention simply made it possible for a given unit of man power to cultivate more land and to distribute its products more rapidly and equitably. With the exception of the credit to be given the mechanical production of chemical fertilizers, thus far negligible in a world-sense, the Age of Steel has not aided agriculture one iota, when computation is made on unit area. In other words, the provisions John Doe raises on his hundred-acre farm have not been increased because of traction plows and steam threshers. But John Doe has had cheap land available and has been able to cultivate more of it than he could by the old hand methods. Yields per acre were actually decreased. What will happen when the new land gives out? It is giving out, giving out rapidly. Well, the result will simply be this: the machine farmer will give way to the hand farmer. The American who now cultivates 26 acres per capita will have to put more man power into his efforts and will approach the Belgian standard of 5 acres per capita. He will get greater yields on a given acre by so doing, even as the Belgian farmer gets greater yields, but the yield per capita will sink slowly downward. So few people seem to appreciate this difference of standard. They look at the English yields of wheat and

---

[1] W. S. Thompson: Population: A Study in Malthusianism (Columbia Univ. Studies in Hist., Econ. and Public Law, Vol. 73, No. 3), New York, 1915, pp. 163-165.

> German yields of potatoes and wonder why the yields per acre in the United States are so low. They are low simply because the United States has had new lands to exploit. The country has been in an era of "increasing returns;" when shallow plowing, incomplete cultivation, and other cheap extensive methods would still yield a fair profit. European agriculture, on the other hand, has long been experiencing the pain of "decreasing returns." Year by year they have been faced with the necessity of getting more and more out of their land, to pay the mounting rentals. They have succeeded remarkably well; but they have only had this success because they have put more toil, more man power into their work. We are now entering on this era of diminishing returns per person in this country. Our yields per acre are rising and will continue to rise. But they will rise because of the increased effort put into the work rather than because of new methods of tilling and of time-saving devices.[2]

These quotations from two of the leading investigators of the problem of population at the present time will be sufficient, it is thought, to indicate that the author is not alone in supposing that this is a real problem, perhaps the most significant one facing mankind today.

It is not my purpose in the present article to do any more than present the general problem. With my colleague, Dr. Lowell J. Reed, I have in preparation a book on the subject, in which the detailed facts as to population growth in various countries will be presented, together with a mathematical theory of population growth, which may be of value in approaching the solution of the world-wide and pressing problem.

---

[2] E. M. East: Future Food Prospects, *World Agriculture*, Vol. 2, 1921, pp. 130–132.